Assignment 1

Reading: Find material on Dijstra's Algorithm and read through carefully at least once. For example: section 8.9 of Module 8 of the Algorithms course. You won't need this material for the assignment below but will need it for the next assignment.

This assignment builds on the CarSim exercises in the Intro module. You will write a controller for the Dubin car (non-accelerative case) to perform a single task and to do so optimally.

But first, let's see how a car simulator can be used without the GUI. Suppose you have written a controller. There are two ways you can test your controller:

- Load your controller into the GUI and run the GUI. This has the advantage that you can see what's going on, but has the disadvantage of being slow. For example, if you were seeking to optimize a parameter and wanted to try a thousand values - it could take a lot of time.
- Alternatively, you can create an instance of the appropriate simulator and use it directly.

Here's an example of using an instance of `SimpleCarSimulator` (for the unicycle, say):

```
public class SimpleCarControlTest {
    public static void main (String[] argv)
    {
        // Build an instance of the simulator. Note: no obstacles in this example.
        // The constructor: isAccel=false, isUnicycle=true
        SimpleCarSimulator simulator = new SimpleCarSimulator (false, true);
        simulator.init (50, 50, 0, null);

        // This example moves the unicycle from (50,50) to (550,50).
        double x = 50;

        while (x < 550) {

            // Pass the controls (v=10, theta=0) to the simulator. DeltaT=0.1.
            simulator.nextStep (10, 0, 0.1);

            // Now extract the new location and other info.
            double t = simulator.getTime ();
            x = simulator.getX ();
            double y = simulator.getY ();

            // Display.
            System.out.println ("t=" + t + " x=" + x + " y=" + y);

            // The CarGUI merely adds an animation delay and drawing here.

        } //end-while

    }
}
```

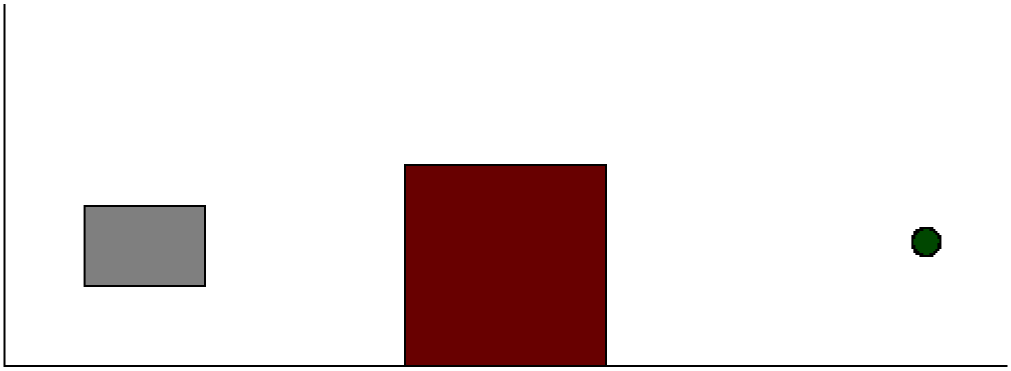
To use the `DubinCarSimulator`, your code would be similar:

```
public class DubinCarControlTest {
    public static void main (String[] argv)
    {
        // Build an instance of the simulator. Note: no obstacles in this example.
        // The constructor: isAccel=false
        DubinCarSimulator simulator = new DubinCarSimulator (false);
        simulator.init (50, 50, 0, null);

        // This example moves the car from (50,50) to (550,50).
        double x = 50;

        while (x < 550) {

            // Pass the controls (v1=10, v2=10) to the simulator. DeltaT=0.1.
            simulator.nextStep (10, 10, 0.1);

            // Now extract the new location and other info.
            double t = simulator.getTime ();
            x = simulator.getX ();
            double y = simulator.getY ();

            // Display.
            System.out.println ("t=" + t + " x=" + x + " y=" + y);

        } //end-while

    }
}
```

You are to use the configuration in Scene-3:

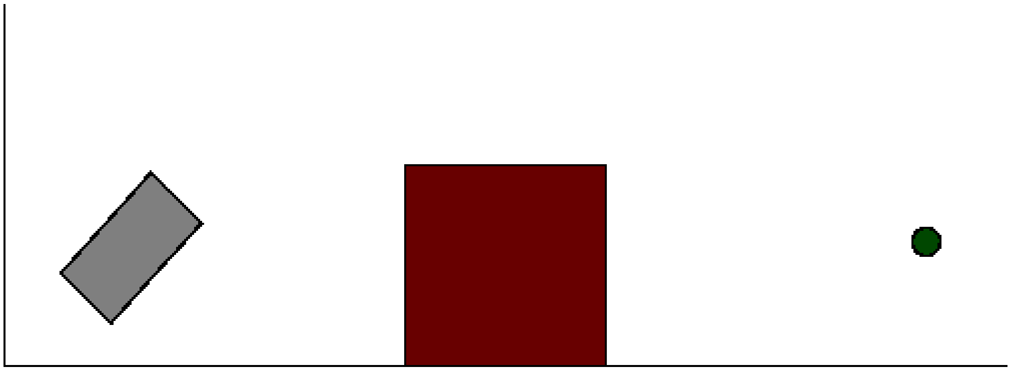
- The car starts at (50, 50) and pointing right (theta=0).
- There is an obstacle - a rectangle with top-left corner at (150,100) and width=100, height=100.
- The target is at (500,50).

Thus, the initial position is:

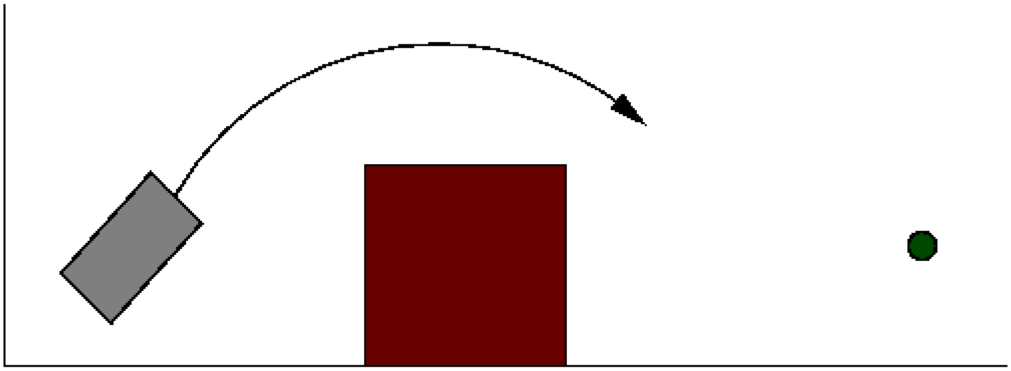


The ultimate goal is to reach the target quickly and in the orientation facing rightwards. However, you are to do this in four discrete phases:

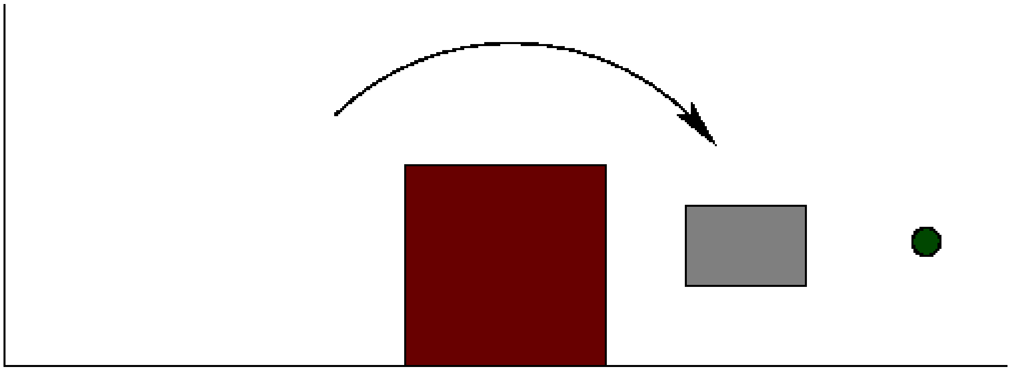
- **Phase 1**: Rotate the car so that it points at an angle of A degrees (for example A = 45 degrees).



- **Phase 2**: Then adjust the two wheel velocities (v1=right-wheel-velocity, v2=left-wheel-velocity) so that they are at a fixed ratio. If the ratio is selected appropriately, the car will turn in an arc all the way around the obstacle to "hit" the target. If it doesn't hit the target, it will at least hit the horizontal line y=50.



- **Phase 3**: Turn the car so that it is facing right.



- **Phase 4**: If needed, move the car rightwards until it reaches the target.

You should experiment with various values of A, v1 and v2 to see which values get you to the target (and facing rightwards) the soonest. *Write code to systematically try different values of A, v1 and v2*, using the GUI-less simulator. This latter program is different than the controller that uses the best values. Then, when you have the optimal values, use these in your controller so that the version loaded into the GUI uses the optimal values.

Guidelines:

- You are really going to write two sets of code. The first is going to be the code that experiments with control parameters and *searches* in the space of control-parameter values for optimal parameters. This does not need a GUI. The second is to use the results of your search (optimal parameters) and code those up in a controller that can be uploaded into the GUI. The idea is that you would *develop* your optimal strategy without the GUI by directly experimenting with the controls as shown above in the `DubinCarControlTest` example. Then, after you know your optimal control strategy, you would implement it in a controller that would be uploaded into the GUI. Thus, the development part that uses the `DubinCarSimulator` does not need a `move()` method or anything like that.

- Your code for the controller should be written in the `move()` method of your controller so that, we can see your controller at work using the GUI, and with your best values of A, v1 and v2. To understand how the GUI works, think of the `move()` method as the "intelligence" in control. This is where you decide on the control parameters of the vehicle. However, the `move()` method does not itself return the control values. Instead, the simulator calls your `getControl()` method to get each control value, right after your `move()` method is called.
- To have your controller run in the GUI, your controller needs to implement the CarController interface.
- You can call several useful methods in the SensorPack in the such as:
  - `getX()` and `getY()` for the current location of the vehicle.
  - `getTheta()` for the current orientation.
  - `getTime()` for the current time.

  The sensor-pack is passed to your controller by the GUI in the into your controller's `init()` method. You should save this object reference so that you can use it in your `move()` method. Note: the position and orientation values will work correctly after `move()` is called at least once.
- The GUI has two levels of accuracy. You can use the lower one, which results in termination if the distance to the target is within 25 pixels.
- Do NOT change `deltaT` so that we have a consistent comparison across all students.

Submission:

- Make sure all *your* Java classes are named such have your username is embedded in each class name. This is to avoid name clashes with other students. Thus, if your username is `karel`, you can call your controller `KarelCarController.java`.
- Place all your code, including the CarSim code in a directory called `karel-a1`
- Name your zip file `karel-a1.zip` (for username `karel`).
- Upload your zip file to Blackboard under "Assignment 1".